Identification of Genes Encoding the Folate- and Thiamine-Binding Membrane Proteins in Firmicutes

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Published in:
Journal of Bacteriology

DOI:
10.1128/JB.01070-08

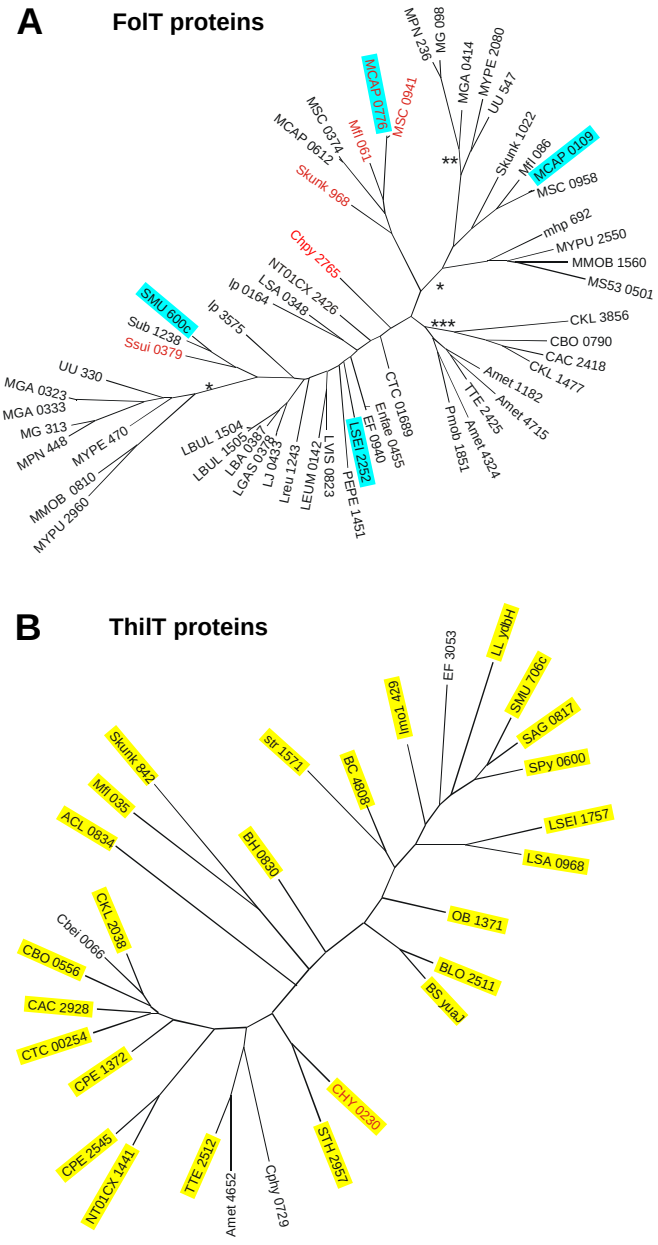
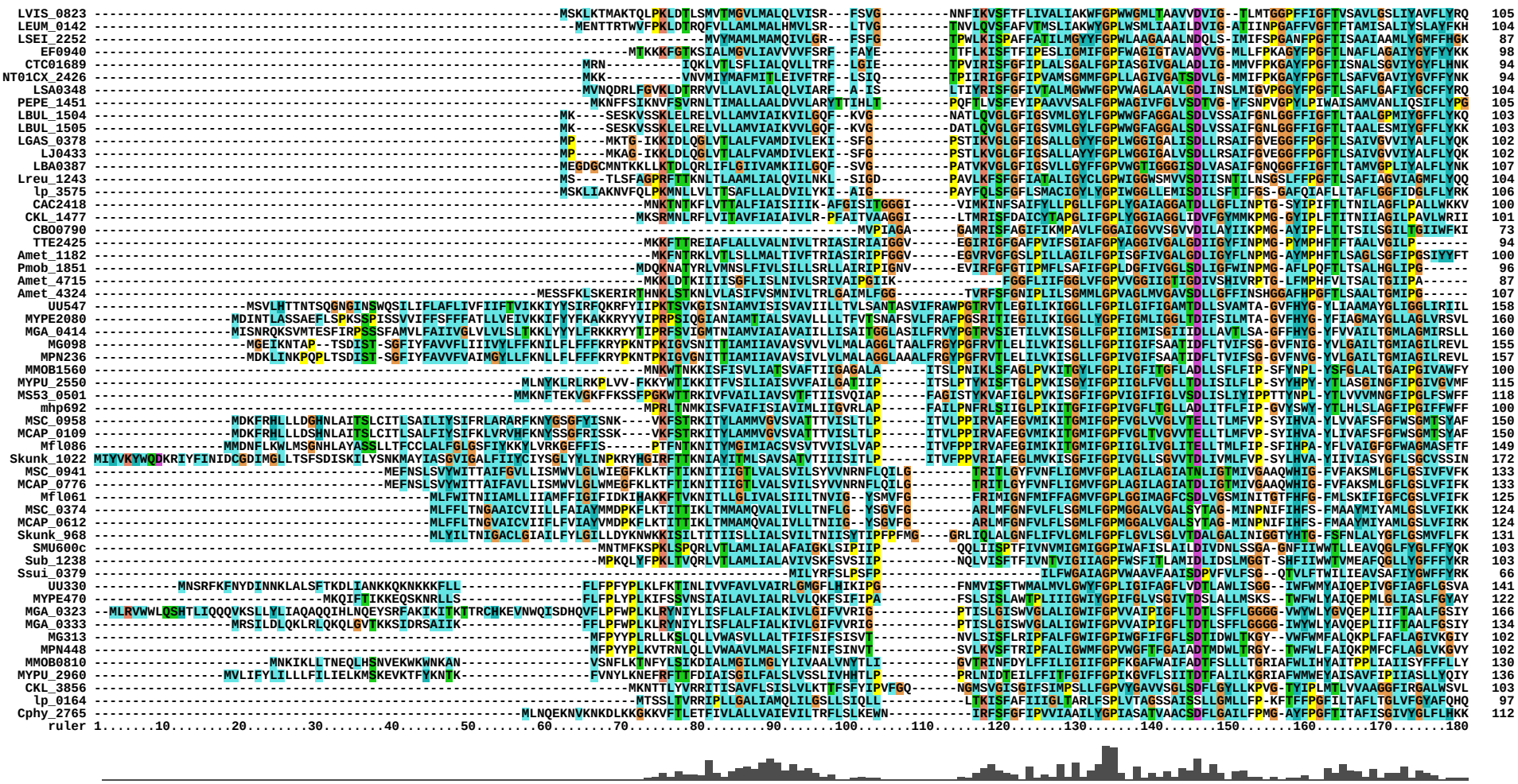
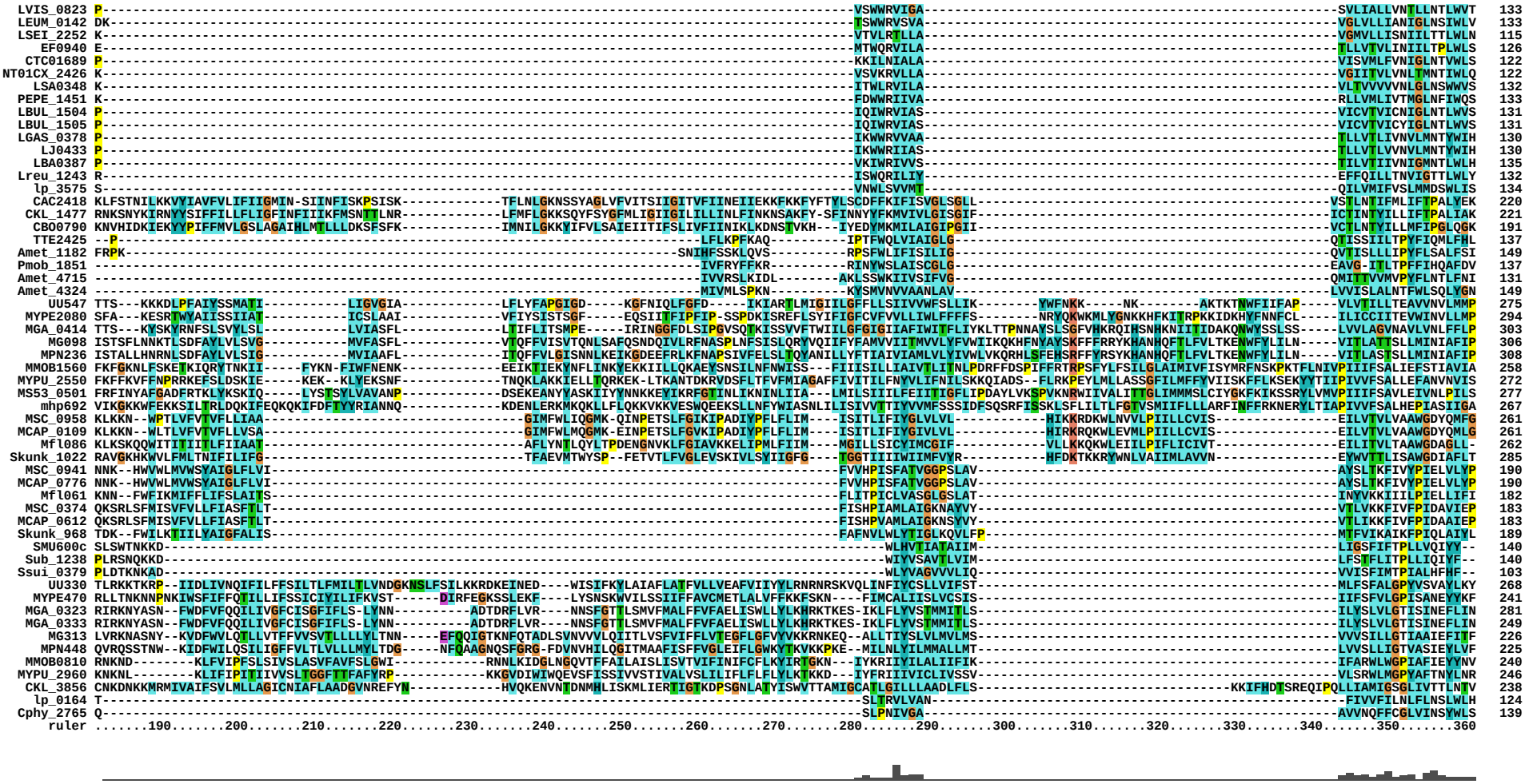


FIG. S1. Phylogenetic analysis of FolT and ThiT family proteins. After sequence alignment with ClustalW, the PHYLIP package was used to construct maximum likelihood trees, including bootstrapping with 100 replicates and drawing of a consensus tree. Genome abbreviations are listed in Supplemental Table 1. (A) Tree of FolT family proteins. The *folT* genes encoding proteins shown in red cluster with the folate salvage gene *folC*. Proteins highlighted in blue were shown in this study to bind folates. Asterisks indicate special features, as follows: *, two groups of *Mycoplasma* proteins with an insertion (~100-residues) containing two transmembrane domains after the third transmembrane domain; **, three *Mycoplasma* proteins with an additional hydrophilic C-terminal domain (~100 residues) similar to aspartyltRNA amidotransferase subunit C; ***, four *Clostridium* proteins with an insertion (~85 residues) containing two transmembrane domains after the third transmembrane domain. (B) Tree of ThiT family proteins. The *thiT* gene encoding the protein shown in red clusters with the thiamine salvage gene *thiN* (thiamine pyrophosphokinase). Proteins highlighted in yellow are encoded by *thiT* genes that are preceded by a thiamine pyrophosphate riboswitch.

Fig. S2. Sequence alignment of FolT proteins

Histograms below alignment show the degree of residue conservation at each position

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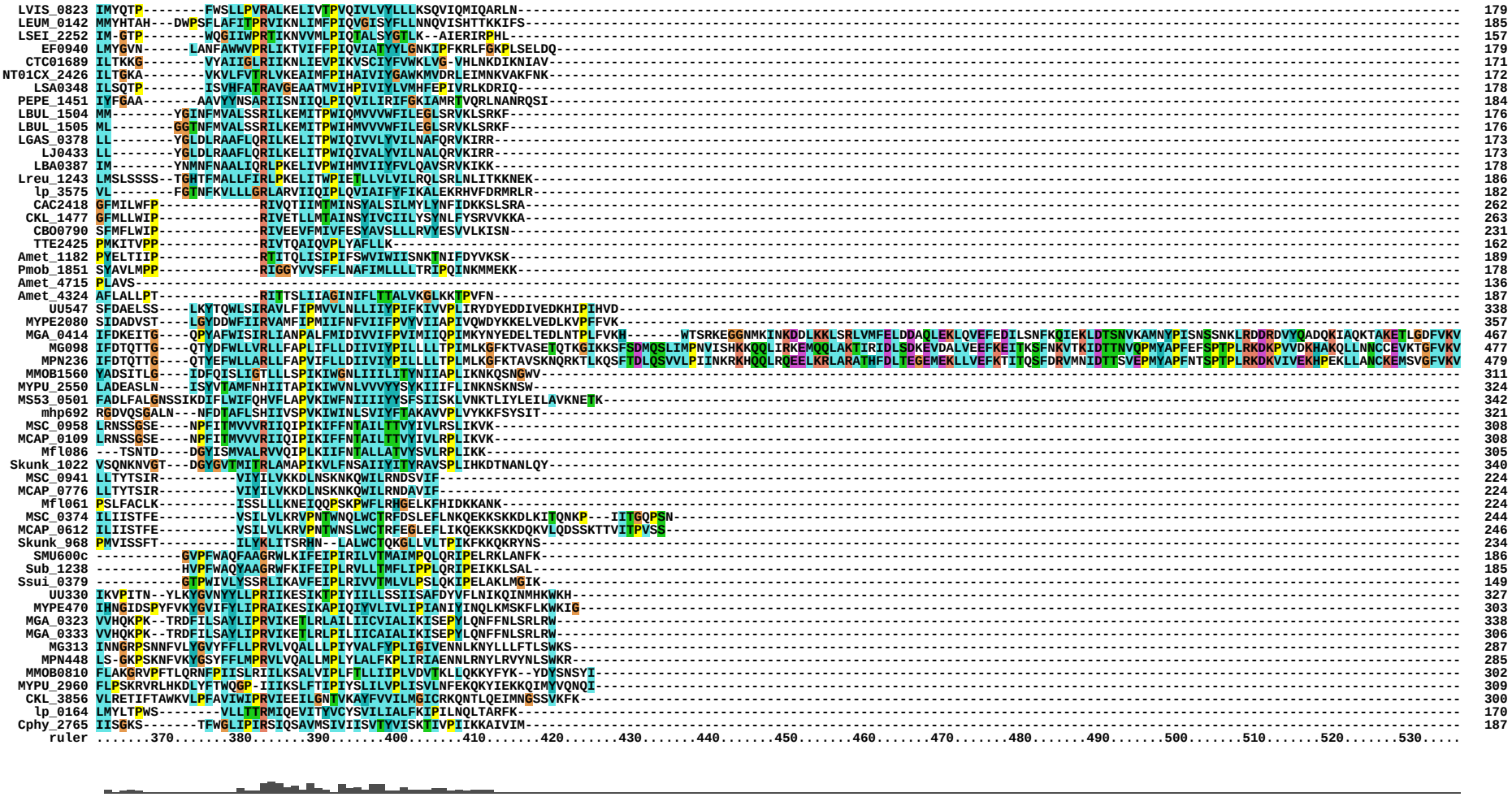
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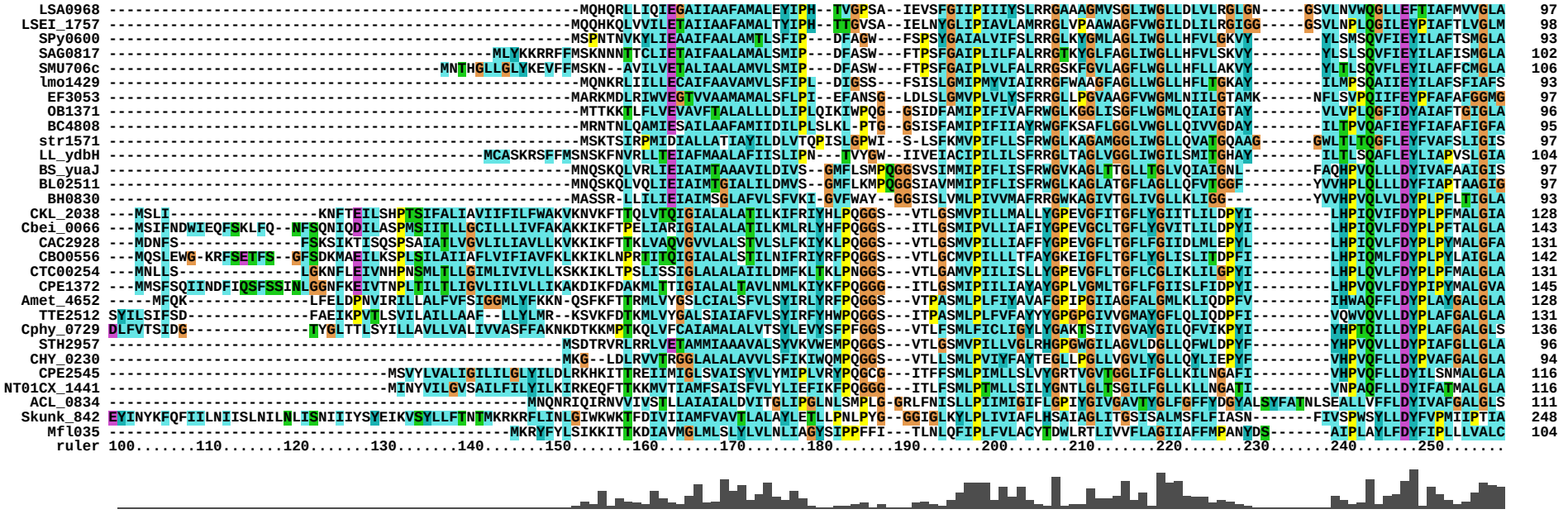
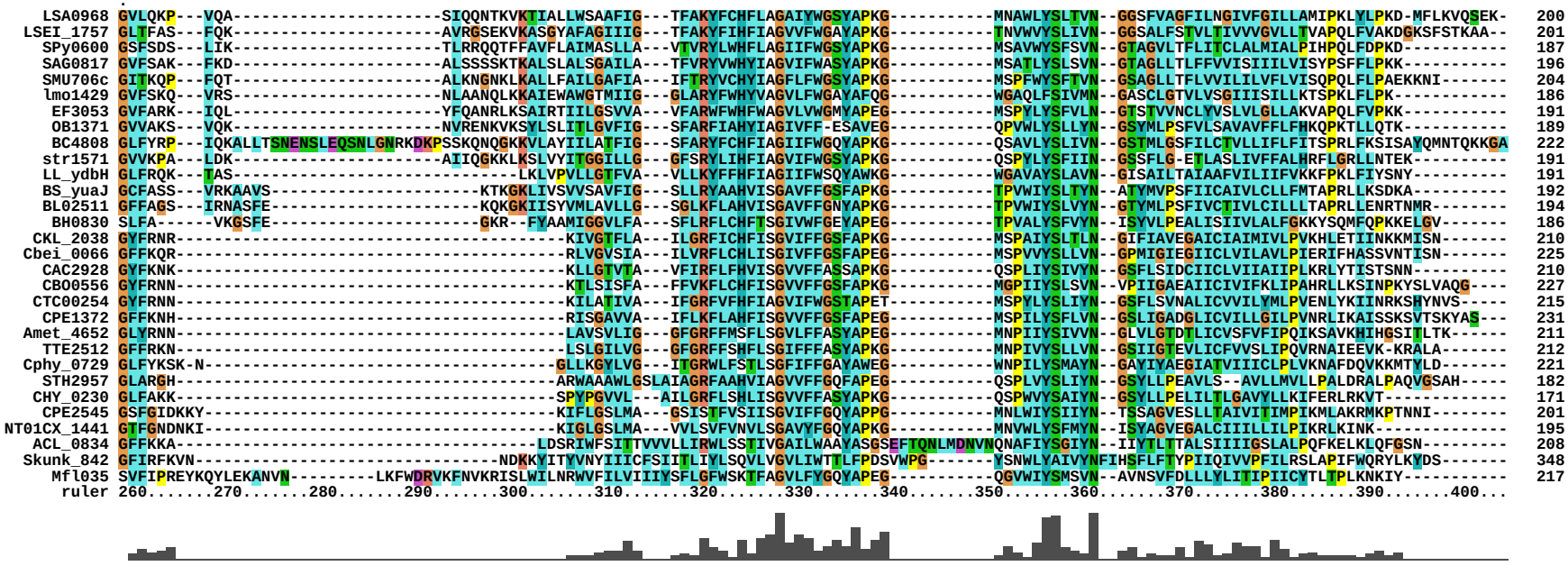
Fig. S3. Sequence alignment of ThiT proteins

Histograms below alignment show the degree of residue conservation at each position

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Amet_4652 GLYRNN----------LAVSVLIG---GFGRFFMSFLSGVLFFASYAPEG----------MNPIIYSIVVN--GLVLGTDTLICVSFVFIPQIKSAVKHIHGSITLTK------ 211
TTE2512 GFFRKN----------LSLGILVG---GFGRFFSHFLSGIFFFASYAPKG----------MNPIVYSLLVN--GSIIGTEVLICFVVSLIPQVRNAIEEVK-KRALA------- 212
Cphy_0729 GLFYKSK-N----------GLLKGYLVG---ITGRWLFSTLSGFIFFGAYAWEG----------WNPILYSMAYN--GAYIYAEGIATVIIICLPLVKNAFDQVKKMTYLD------- 221
STH2957 GLARGH----------ARWAAAWLGSLAIAGRFAAHVIAGVVFFGQFAPEG----------QSPLVYSLIYN--GSYLLPEAVLS--AVLLMVLLPALDRALPAQVGSAH----- 182
CHY_0230 GLFAKK----------SPYPGVVL---AILGRFLSHLISGVVFFASYAPKG----------QSPWVYSAIYN--GSYLLPELILTLGAVYLLKIFERLRKVT---------- 171
CPE2545 GSFGIDKKY----------KIFLGSLMA---GSISTFVSIISGVIFFGQYAPPG----------MNLWIYSIIYN--TSSAGVESLLTAIVITIMPIKMLAKRMKPTNNI-------- 201
NT01CX_1441 GTFGNDNKI----------KIGLGSLMA---VVLSVFVNVLSGAVYFGQYAPKG----------MNVWLYSFMYN--ISYAGVEGALCIIILLILPIKRLKINK---------- 195
ACL_0834 GFFKKA----------LDSRIWFSITTVVVLLIRWLSSTIVGAILWAAYASGSEFTQNLMDNVNQNAFIYSGIYN--IIYTLTTALSIIIGSLALPQFKELKLQFGSN--------- 208
Skunk_842 GFIRFKVN----------NDKKYITYVNYIIICFSIITLIYLSQVLVGVLIWTTLFPDSVWPG-------YSNWLYAIVYNFIHSFLFTYPIIQIVVPFILRSLAPIFWQRYLKYDS------- 348
Mfl035 SVFIPREYKQYLEKANVN---------LKFWDRVKFNVKRISLWILNRWVFILVIIIYSFLGFWSKTFAGVLFYGQYAPEG----------QGVWIYSMSVN--AVNSVFDLLLYLITIPIICYTLTPLKNKIY---------- 217
ruler 260.....270.....280.....290.....300.....310.....320.....330.....340.....350.....360.....370.....380.....390.....400...

Supplemental Table 1

Locus tags of FolT and ThiT proteins identified in various bacterial genomes

FolT proteins

Organism	Locus tag
Clostridium acetobutylicum ATCC 824	CAC2418
Clostridium botulinum A str. ATCC 3502	CBO0790
Clostridium kluyveri DSM 555	CKL 3856
Clostridium kluyveri DSM 555	CKL 1477
Clostridium novyi NT	NT01CX_2426
Clostridium phytofermentans ISDg	Cphy_2765
Clostridium tetani E88	CTC01689
Enterococcus faecium DO	EFAE 0455
Enterococcus faecalis V583	EF0940
Lactobacillus acidophilus NCFM	LBA0387
Lactobacillus brevis ATCC 367	LVIS_0823
Lactobacillus casei ATCC 334	LSEI 2252
Lactobacillus delbrueckii subsp. *bulgaricus* ATCC BAA-365	LBUL 1505
Lactobacillus delbrueckii subsp. *bulgaricus* ATCC BAA-365	LBUL 1504
Lactobacillus gasseri ATCC 33323	LGAS 0378
Lactobacillus johnsonii NCC 533	LJ0433
Lactobacillus plantarum WCFS1	lp_3575
Lactobacillus plantarum WCFS1	lp_0164
Lactobacillus reuteri F275	LREU 1243
Lactobacillus sakei subsp. sakei 23K	LSA0348
Leuconostoc mesenteroides subsp. mesenteroides ATCC 8293	LEUM_0142
Mesoplasma florum L1	MFL061
Mesoplasma florum L1	Mfl086
Mycoplasma capricolum subsp. capricolum ATCC 27343	MCAP_0612
Mycoplasma capricolum subsp. capricolum ATCC 27343	MCAP_0776
Mycoplasma capricolum subsp. capricolum ATCC 27343	MCAP_0109
Mycoplasma gallisepticum R	MGA 0333
Mycoplasma gallisepticum R	MGA 0323
Mycoplasma gallisepticum R	MGA 0414
Mycoplasma genitalium G37	MG_313
Mycoplasma genitalium G37	MG_098
Mycoplasma hyopneumoniae 232	MHP692
Mycoplasma mobile 163K	MMOB0810
Mycoplasma mobile 163K	MMOB1560
Mycoplasma mycoides subsp. mycoides SC str. PG1	MSC 0374
Mycoplasma mycoides subsp. mycoides SC str. PG1	MSC 0941
Mycoplasma mycoides subsp. mycoides SC str. PG1	MSC 0958
Mycoplasma penetrans HF2	MYPE470
Mycoplasma penetrans HF2	MYPE2080
Mycoplasma pneumoniae M129	MPN448
Mycoplasma pneumoniae M129	MPN236
Mycoplasma pulmonis UAB CTIP	MYPU 2960
Mycoplasma pulmonis UAB CTIP	MYPU 2550
Mycoplasma synoviae 53	MS53 0501
Petrotoga mobilis SJ95	PMOB 1851
Pediococcus pentosaceus ATCC 25745	PEPE 1451
Spiroplasma kunkelii CR2-3X	Skunk_968
Spiroplasma kunkelii CR2-3X	Skunk_1022
Streptococcus mutans UA159	SMU.600c
Streptococcus suis 89/1591	Ssui_0379
Streptococcus uberis 0140J	SUB1238
Ureaplasma parvum serovar 3 ATCC 700970	UU330
Ureaplasma parvum serovar 3 ATCC 700970	UU547

ThiT proteins

Organism	Locus tag
Acholeplasma laidlawii PG-8A	ACL_0834
Alkaliphilus metalliredigens QYMF	Amet_4652
Bacillus halodurans C-125	BH0830
Bacillus cereus ATCC 14579	BC4808
Bacillus licheniformis ATCC 14580	BL02511
Bacillus subtilis subsp. subtilis str. 168	BSU30990
Carboxydothermus hydrogenoformans Z-2901	CHY_0230
Clostridium acetobutylicum ATCC 824	CAC2928
Clostridium beijerinckii NCIMB 8052	Cbei_0066
Clostridium botulinum A str. ATCC 3502	CBO0556
Clostridium kluyveri DSM 555	CKL_2038
Clostridium perfringens str. 13	CPE2545
Clostridium perfringens str. 13	CPE1372
Clostridium phytofermentans ISDg	Cphy_0729
Clostridium tetani E88	CTC00254
Enterococcus faecalis V583	EF3053
Lactobacillus casei ATCC 334	LSEI_1757
Lactococcus lactis subsp. lactis Il1403	L116212
Listeria monocytogenes EGD-e	lmo1429
Oceanobacillus iheyensis HTE831	OB1371
Spiroplasma kunkelii CR2-3X	Skunk_842
Streptococcus agalactiae 2603V/R	SAG0817
Streptococcus mutans UA159	SMU.706c
Streptococcus pyogenes M1 GAS	YP_602012
Streptococcus thermophilus CNRZ1066	str1571
Symbiobacterium thermophilum IAM 14863	STH2957
Thermoanaerobacter tengcongensis MB4	TTE2512